Circular Motion: Observations

- Object moving along a curved path with **constant speed**
  - Magnitude of velocity: same
  - Direction of velocity: changing
    - Velocity: changing
  - Acceleration is NOT zero!
  - **Net force acting on an object is NOT zero**
  - “**Centripetal force**”

Figure 4.17
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$$\vec{F}_{net} = m\vec{a}$$

Figure 6.2
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Uniform circular motion

Constant speed, or,
constant magnitude of velocity

Motion along a circle:
Changing direction of velocity

Uniform Circular Motion

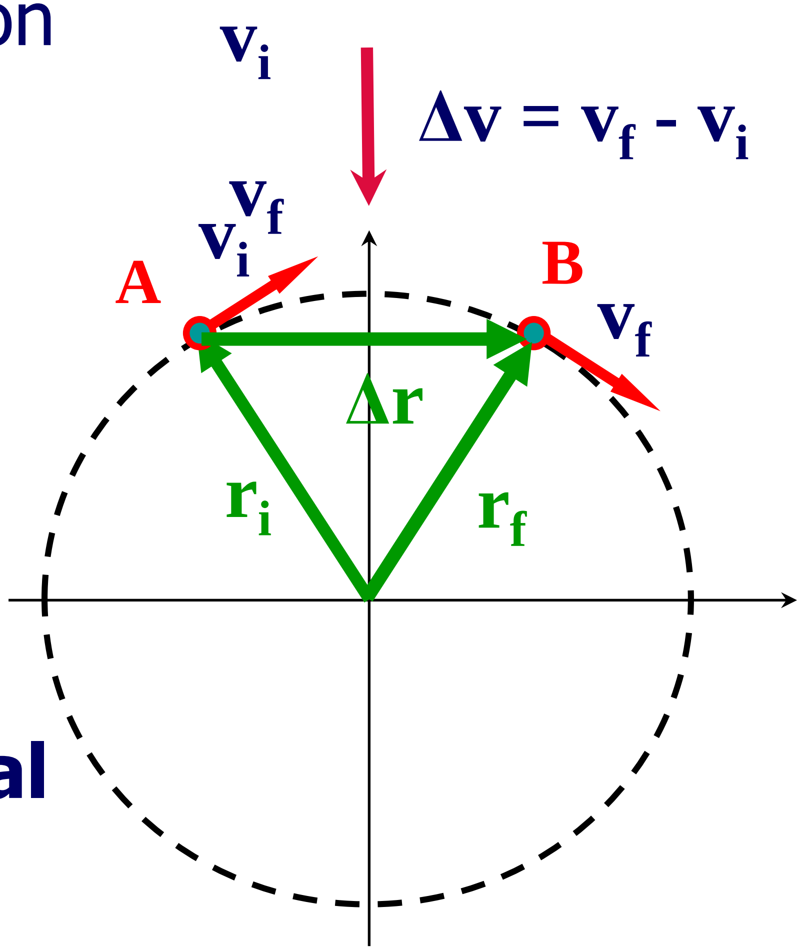
- Centripetal acceleration

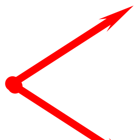
$$\frac{\Delta v}{v} = \frac{\Delta r}{r} \quad \text{so,} \quad \Delta v = \frac{v \Delta r}{r}$$

$$\frac{\Delta v}{\Delta t} = \frac{\Delta r}{\Delta t}\frac{v}{r} = \frac{v^2}{r}$$

$$a_r = \frac{\Delta v}{\Delta t} = \frac{v^2}{r}$$

- Direction: **Centripetal**



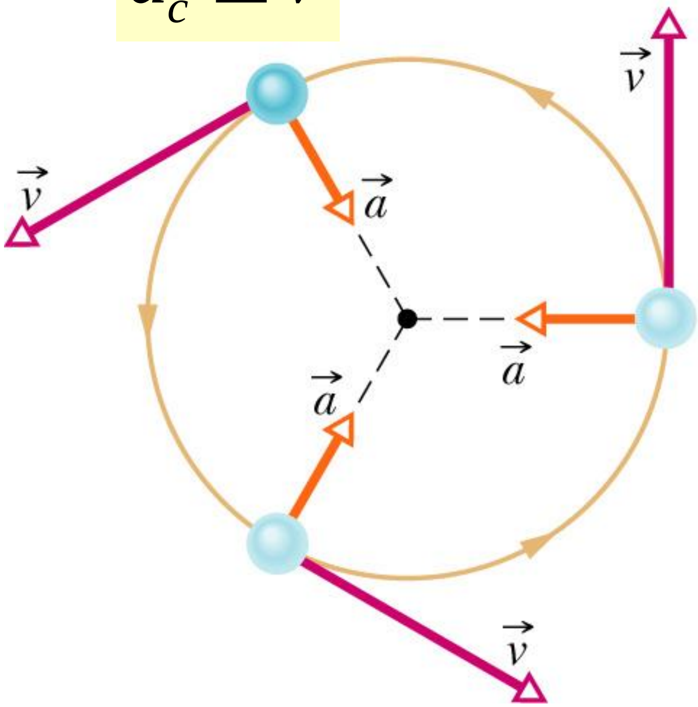


Uniform Circular Motion

- Velocity:
  - Magnitude: constant v
  - The direction of the velocity is tangent to the circle
- Acceleration:
  - Magnitude: $$a_c = \frac{v^2}{r}$$
  - directed toward the center of the circle of motion
- Period:
  - time interval required for one complete revolution of the particle

$$T = \frac{2\pi r}{v}$$

$$\vec{a}_c \perp \vec{v}$$



Relative Velocity

Figure 4.22
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Figure 4.23
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$$\mathbf{r}' = \mathbf{r} - \mathbf{v}_0 t \qquad \frac{d\mathbf{r}'}{dt} = \frac{d\mathbf{r}}{dt} - \mathbf{v}_0 \qquad \frac{d\mathbf{v}'}{dt} = \frac{d\mathbf{v}}{dt} - \frac{d\mathbf{v}_0}{dt}$$

$$\mathbf{v}' = \mathbf{v} - \mathbf{v}_0$$

Because $\mathbf{v}_0$ is constant, $d\mathbf{v}_0/dt = 0$. Therefore, we conclude that $\mathbf{a}' = \mathbf{a}$ because $\mathbf{a}' = d\mathbf{v}'/dt$ and $\mathbf{a} = d\mathbf{v}/dt$.